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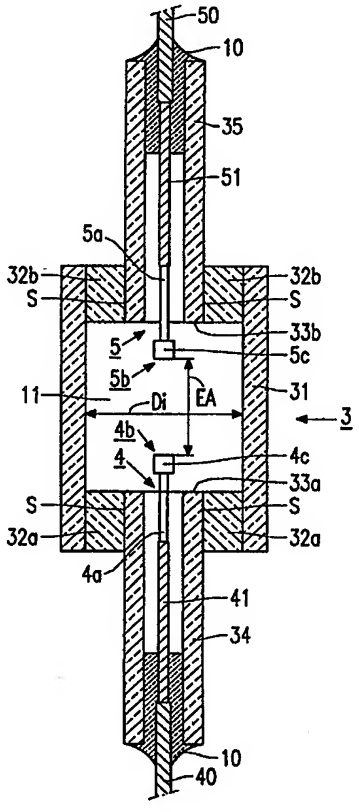
(54) Title: MERCURY FREE METAL HALIDE LAMP

(57) Abstract

The invention relates to a metal halide lamp provided with a discharge vessel with a ceramic wall which encloses a discharge space in which besides a rare gas also an ionizable filling comprising at least NaJ is present, two electrodes having tips with a mutual distance EA being arranged in said discharge space which discharge vessel has an internal diameter Di over at least the electrode distance EA. The discharge space is according to the invention Hg–free and the ionizable filling further comprises Zn and the electrode distance EA and the internal diameter Di comply with the relation $1 \leq EA/Di \leq 4$.



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MERCURY FREE METAL HALIDE LAMP

The invention relates to a metal halide lamp provided with a discharge vessel with a ceramic wall which encloses a discharge space in which besides a rare gas also an ionizable filling comprising at least NaJ is present, two electrodes having tips with a mutual distance EA being arranged in said discharge space which discharge vessel has an internal diameter Di over at least the electrode distance EA.

A lamp of the kind mentioned in the opening paragraph is known from EP-A-0 215 524 (PHN 11.485). The known lamp, in which a high luminous efficacy goes hand in hand with excellent color properties (inter alia a general color rendering index $R_a \geq 70$ and a color temperature T_c of between 2600 and 4000 K), is highly suitable as a light source for inter alia interior lighting. This lamp construction is based on the recognition that a good color rendering is possible when sodium halide is used as a filling ingredient of a lamp and a strong widening and inversion of the Na emission in the Na-D lines takes place during lamp operation. This requires a high coldest-spot temperature T_{kp} in the discharge vessel of, for example, 1170 K (900 °C). Inversion and widening of the Na-D lines imply that they take the shape of an emission band in the spectrum with two maxima at a mutual distance of $\Delta\lambda$. The requirement that T_{kp} should have a high value excludes the use of quartz or quartz glass for the discharge vessel wall and renders the use of a ceramic material for the discharge vessel wall necessary.

The term "ceramic wall" in the present description and claims is understood to cover a wall of metal oxide such as, for example, sapphire or densely sintered polycrystalline Al_2O_3 as well as metal nitride, for example AlN.

The known lamp combines a good color rendering with a comparatively wide range of the color temperature. The filling of the discharge vessel comprises at least Hg, Na halide and Tl halide. In addition, the discharge vessel preferably contains at least one element from the group formed by Sc, La, and the lanthanides Dy, Tm, Ho, and Er.

The known lamp has a lamp voltage during stable operation of between 70 and 110V, being the general accepted range for discharge lamps. In the known lamp this

voltage is mainly sustained during stable operation by the mercury which forms part of the filling. However Hg forms a heavy burden on the environment in case it would be released, for instance at the end of the life of the lamp.

The invention has for its object to provide a measure for obtaining a metal halide lamp with a mercury free filling which is electrical retrofit with the known lamp.

According to the invention, a lamp of the kind mentioned in the opening paragraph is for this purpose characterized in that the discharge space is Hg-free and the ionizable filling further comprises Zn and in that the electrode distance EA and the internal diameter Di comply with the relation $1 \leq EA/Di \leq 4$.

Surprisingly it is possible to arrive with the lamp according to the invention at comparable properties with regard to luminous efficacy and colour properties (inter alia a general color rendering index $R_a \geq 70$ and a color temperature T_c of between 2600 and 4000 K) as in case of the known lamp and have the advantage of being Hg-free. Values of $EA/Di > 4$ lead to extreme high values of the lamp voltage during stable operation resulting in non-retrofit lamps. Otherwise values of $EA/Di < 1$ are not used because at such values the coldest spot temperature T_{kp} easily assumes a too low value which will result in unacceptable colour properties of the light emitted by the lamp. Preferable the Zn is contained in metallic form in a quantity of at least 100 μmol/cm^3, as to have also in the discharge vessel construction of the known lamp a sufficient amount inside the actual discharge space.

According to a further embodiment of the lamp according to the invention the Zn is at least partly contained as compound ZnJ_2 in a quantity of at most 20 μmol/cm^3. The use of ZnJ_2 is advantage for improving the luminous efficacy of the lamp without altering its colour properties. The amount should be restricted to the mentioned value as to prevent too large a curvature of the discharge arc between the electrodes. Besides ZnJ_2 has the advantage that it can be regarded to be chemically inert with respect to the fillings of the known lamp. If the Zn is contained exclusively in the form of the compound ZnJ_2, the quantity should at least be 4μmol/cm^3. It has appeared that because the compound ZnJ_2 will be fully evaporated during lamp operation the said quantity can suffice to arrive at a lamp voltage suitable for the lamp being retrofit.

Preferable the rare gas is Xe with a fill pressure of at least 400mbar. Because of its relative heavy weight Xe has excellent properties as a buffer gas and thus a favourable influence on

the luminous efficacy of the lamp. Ar as the rare gas is however also suitable.

In a lamp according to the invention preferable the ionizable filling comprises constituents with quantities satisfying ranges in μmol/cm^3 as indicated:

metallic Zn 0 - 2000

ZnJ_2 0 - 20

NaJ 20 - 200

TlJ 0 - 30

RE-jodide 0 - 40,

with RE being at least one of the elements formed by the group of In, Sc, Y and the lanthanides, and in that in case the Zn is exclusively contained as the compound ZnJ_2, the quantity of ZnJ_2 is at least 4 μmol/cm^3. Thus the lamp will be electrical retrofit with respect to the known lamp and also have comparable colour properties.

In an advantageous embodiment the lamp according to the invention has a power density measured over the electrode distance EA of at least 3W/cm and at most 130W/cm. By fulfilling this requirement the invented lamp has a constructive length which is comparable with the known lamp. This has the advantage that the lamp can readily be used in existing fixtures.

The above and further aspects of the lamp according to the invention will be explained in more detail with reference to a drawing (not true to scale).

In the drawing:

Fig. 1 diagrammatically shows a lamp according to the invention, and

Fig. 2 shows the discharge vessel of the lamp of Fig. 1 in detail.

Fig. 1 shows a metal halide lamp provided with a discharge vessel 3 having a ceramic wall which encloses a discharge space 11 containing an ionizable filling. Two electrodes whose tips are at a mutual distance EA are arranged in the discharge space, and the discharge vessel has an internal diameter Di at least over the distance EA. The discharge vessel is closed at one side by means of a ceramic projecting plug 34, 35 which encloses a current lead-through conductor (Fig. 2: 40, 41, 50, 51) to an electrode 4, 5 positioned in the discharge vessel with a narrow intervening space and is connected to this conductor in a gastight manner by means of a melting-ceramic joint (Fig. 2: 10) at an end

remote from the discharge space. The discharge vessel is surrounded by an outer bulb 1 which is provided with a lamp cap 2 at one end. A discharge will extend between the electrodes 4, 5 when the lamp is operating. The electrode 4 is connected to a first electrical contact forming part of the lamp cap 2 via a current conductor 8. The electrode 5 is connected to a second electrical contact forming part of the lamp cap 2 via a current conductor 9. The discharge vessel, shown in more detail in Fig. 2 (not true to scale), has a ceramic wall and is formed from a cylindrical part with an internal diameter Di which is bounded at either end by a respective end wall portion 32a, 32b, each end wall portion 32a, 32b forming an end surface 33a, 33b of the discharge space. The end wall portions each have an opening in which a ceramic projecting plug 34, 35 is fastened in a gastight manner in the end wall portion 32a, 32b by means of a sintered joint S. The ceramic projecting plugs 34, 35 each narrowly enclose a current lead-through conductor 40, 41, 50, 51 of a relevant electrode 4, 5 having a tip 4b, 5b. The current lead-through conductor is connected to the ceramic projecting plug 34, 35 in a gastight manner by means of a melting-ceramic joint 10 at the side remote from the discharge space.

The electrode tips 4b, 5b are arranged at a mutual distance EA. The current lead-through conductors each comprise a halide-resistant portion 41, 51, for example in the form of a Mo-Al_2O_3 cermet and a portion 40, 50 which is fastened to a respective end plug 34, 35 in a gastight manner by means of the melting-ceramic joint 10. The melting-ceramic joint extends over some distance, for example approximately 1 mm, over the Mo cermet 40, 41. It is possible for the parts 41, 51 to be formed in an alternative manner instead of from a Mo-Al_2O_3 cermet. Other possible constructions are known, for example, from EP-0 587 238 (US-A-5,424,609). A particularly suitable construction was found to be a halide-resistant coil applied around a pin of the same material. Mo is very suitable for use as material which is to a high degree halide-resistant. The parts 40, 50 are made from a metal whose coefficient of expansion corresponds very well to that of the end plugs. Nb, for example, is a highly suitable material therefor. The parts 40, 50 are connected to the current conductors 8, 9 in a manner not shown in any detail. The lead-through construction described renders it possible to operate the lamp in any burning position as desired.

Each of the electrodes 4, 5 comprises an electrode rod 4a, 5a which is provided with a coiling 4c, 5c near the tip 4b, 5b. The projecting ceramic plugs are fastened in the end wall portions 32a and 32b in a gastight manner by means of a sintered joint S. The electrode tips then lie between the end surfaces 33a, 33b formed by the end wall portions. In an alternative embodiment of a lamp according to the invention, the projecting

ceramic plugs 34, 35 are recessed behind the end wall portions 32a, 32b. In that case the electrode tips lie substantially in the end surfaces 33a, 33b defined by the end wall portions.

In a practical realization of a lamp according to the invention as shown in the drawing, the rated lamp power is 75W and an arc voltage of 86V. The lamp was operated on an electronic supply, type EMC 070 W, make Philips. The mutual distance EA between the electrodes is 9mm and the internal diameter Di over this distance is 4.5 mm, resulting in a value for the relation EA/Di of 2. The lamp has a luminous efficacy of 84 lm/W. The generated light has a general color rendering index R_a of 84 and a color temperature T_c of 2880K corresponding to colour point coordinates (x,y) (0.436;0.387). The discharge vessel of the lamp had a filling consisting of 12mg Zn, 5.0mg NaJ, 1.0mg TlJ, 2.0mg DyJ_3 and Xe with a fill pressure at room temperature of 400mbar. The total volume of the discharge vessel is 0.175cm^3. The filling quantities therefor correspond to 1050μmol/cm^3, 190μmol/cm^3, 17μmol/cm^3 and 21μmol/cm^3.

In a further practical embodiment with the same geometry, the discharge vessel filling contained besides NaJ, TlJ and DyJ_3 only 10mg Zn, corresponding to 874μmol/cm^3, and a Xe fill pressure at room temperature of 2bar. The initial values for lamp power, luminous efficacy, general colour index R_a and colour temperature T_c are; 74W, 88lm/W, 78 and 2980K. As the lamp has an arc voltage of 94V it is electrical retrofit with the known lamp.

From a further practical embodiment the filling of the discharge lamp contains besides metallic Zn also ZnJ_2 with a filling quantity of 0.9mg, resulting in an operating pressure of 2.5bar and corresponding to 13μmol/cm^3. With the electrode distance being unchanged and the internal diameter Di slightly increased to 5.1mm the value of EA/Di is reduced to 1.7. The lamp voltage is reduced to 85V. The color temperature T_c is increased to 3090K corresponding to colour point coordinates (x,y) (0.429;0.398). The values for the luminous efficacy and the general colour index R_a have only slightly decreased to 86lm/W and 76.

In yet another embodiment the electrode distance is 10.8mm and the internal diameter Di 5.1mm, thus EA/Di=2.1. The filling of the discharge vessel consists of Ar with fill pressure of 400mbar, 8mg of a mixture of NaJ, TlJ and DyJ_3, in a weight ratio of 5:1:2 and 7mg Zn. The lamp has a power of 75W. The lamp which has an initial lamp voltage of 85V, is emitting light with a luminous efficacy of 79lm/W at a color temperature T_c of 2750K and with a value of general colour index R_a of 79. After 100 hours of lamp operation the lamp voltage has increased to 95V. The luminous efficacy has slightly

decreased to 77lm/W whilst the colour temperature T_c and the general colour index R_a have not significantly changed, having the values 2780K and 79.

A practical embodiment of a lamp according to the invention in which the filling includes Zn exclusively in the form of ZnJ_2 is described hereunder. The ceramic discharge vessel has an internal diameter Di of 3.52mm over a distance between the electrodes EA of 12.88mm. The total volume of the discharge vessel is 0.145cm^3. The filling of the discharge vessel contains 0.21mg ZnJ_2, 5mg NaJ, 1mg TlJ, 2mg DyJ_3 and 400mbar Xe at room temperature. The amount of ZnJ_2 corresponds to 4,5μmol/cm^3. The lamp has a nominal power of 75W with a lamp voltage of 71V. The luminous efficacy of the lamp is 75lm/W with a value of 3000K for the colour temperature T_c and of 80 for the general colour index R_a.

CLAIMS:

1. Metal halide lamp provided with a discharge vessel with a ceramic wall which encloses a discharge space in which besides a rare gas also an ionizable filling comprising at least NaJ is present, two electrodes having tips with a mutual distance EA being arranged in said discharge space which discharge vessel has an internal diameter Di over at least the electrode distance EA, characterized in that the discharge space is Hg-free and the ionizable filling further comprises Zn and in that the electrode distance EA and the internal diameter Di comply with the relation $1 \leq EA/Di \leq 4$.

2. Lamp according to claim 1, characterized in that the Zn is contained in metallic form in a quantity of at least 100 μmol/cm^3.

3. Lamp according to claim 1 or 2, characterized in that the Zn is at least partly contained as compound ZnJ_2 in a quantity of at most 20 μmol/cm^3.

4. Lamp according to claim 1 or 3, characterized in that the Zn is contained exclusively in the form of compound ZnJ_2 and the quantity is at least 4μmol/cm^3.

5. Lamp according to claim 1, 2, 3 or 4, characterized in that the rare gas is Xe with a fill pressure of at least 400mbar.

6. Lamp according to claim 1, 2, 3, 4 or 5, characterized in that the ionizable filling comprises constituents with quantities satisfying ranges in μmol/cm^3 as indicated:

metallic Zn 0 - 2000
ZnJ_2 0 - 20
NaJ 20 - 200
TlJ 0 - 30
RE-jodide 0 - 40,

with RE being at least one of the elements formed by the group of In, Sc, Y and the lanthanides, and in that in case the Zn is exclusively contained as the compound ZnJ_2, the quantity of ZnJ_2 is at least 4 μmol/cm^3.

7. Lamp according to any of the preceding claims, characterized in that the lamp has a power density measured over the electrode distance EA of at least 3W/cm and at most 130W/cm.

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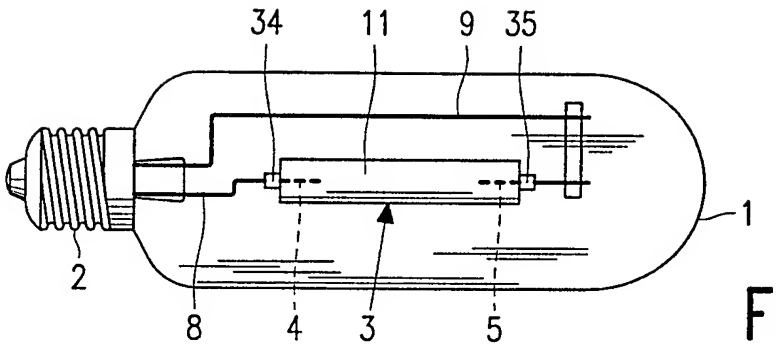
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FIG. 1

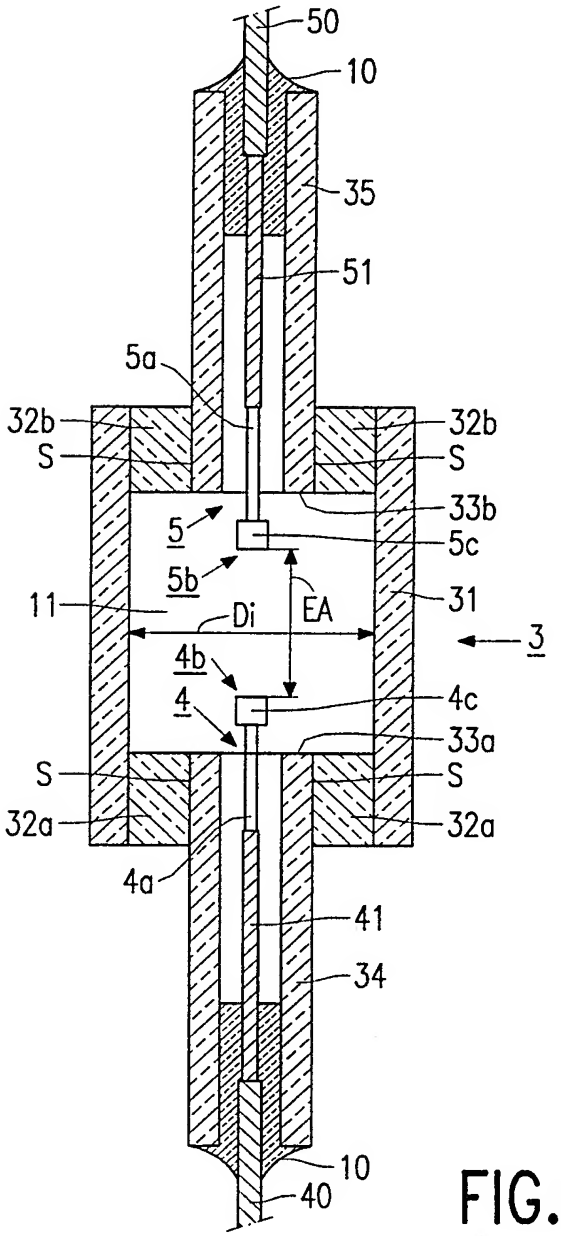
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FIG. 2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB 98/00719

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H01J 61/22
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: H01J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 1280370 A (THE GENERAL ELECTRIC COMPANY LIMITED), 5 July 1972 (05.07.72), page 2, line 28 - line 98; page 3, line 7 - line 26	1-7
A	EP 0215524 A1 (N.V. PHILIPS' GLOEILAMPENFABRIEKEN), 25 March 1987 (25.03.87), page 3, line 12 - line 24	1-7

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INTERNATIONAL SEARCH REPORT

Information on patent family members

27/07/98

International application No.
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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